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Characterization and Energy Estimation of Biomass Co-Firing Based Power Generation

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ABSTRACT

The consumption of energy is increasing steadily with the advancement in the technology. So, it is needed that besides to the current power sources such as water, coal and petroleum etc. different energy sources should be discovered.Biomass is more economically viable for almost all the continents in the world. Biomass is a carbonaceous material and provides both the thermal energy and reduction for oxides. Co-firing with biomass is the one technology, which doesn't require huge investments and also be carried out instantly in a short time in all current thermal plants.The present work is a positive step towards energy and environmental problems facing the world. In this paper, the experimental test is done for calculating the value of calorific value, moisture content, ash content and volatile matter and the fixed carbon content in biomass residue, coalas well as briquettes which are prepared by mixing non-coking coal from Jharkhand mines and the related biomass species in different ratio (coal: biomass = 95:05, 90:10, 85:15, 80:20)and find the finest appropriate ratio for energy generation.

Keywords: Non-woody Biomass, Coal, Proximate Analysis, Co-Firing, Calorific value.

1. INTRODUCTION

In the worldwide scenario the major source of energy generation are Fossil fuels. From the fossil fuels, the world's power supply comes are around 87%. In case of India, the fossil fuels shares more than 90%. Utilization of fossil fuel causes to discharge large amount of pollutants such as sulphur oxides, fly ash, carbon dioxide, and so on. It is dangerous for environment and also for human survival. Due to these causes it has become urgent to explore and enlarge non-conventional energy resources. Therefore biomass is one of the alternative sources of electricity generation. Thus, the development of biomass-based power generation system is thought to be favourable for majority of the developing nations including India. Biomass co-firing with coal is the most common method and has shown the greatest potential for large scale utilization of biomass energy in the near future.

A. Biomass and its classification

In general biomass resources can be mostly classified into two types based on its availability in the natural form woody and non woody biomass.

1.Woody biomass: Woody biomass is characterized by high bulk density, less void age, low ash content, low moisture content, high calorific value. Because of the multitude of advantages of woody biomass its cost is higher, but supply is limited.

2.Non-Woody biomass: The various agricultural crop residues resulting after harvest, organic fraction of municipal solid wastes, manure from confined livestock and poultry operations constitute non-woody biomass. Non-woody biomass is characterized by lower bulk density, higher ash content, higher moisture content and lower calorific value.

B. Biomass Conversion Processes

The advances in bio-energy technologies over the last few decades have enabled a significant increase in the utilization of biomass for power generation. The various technologies available for energy generation from biomass in India are gasification, combustion, co-firing and bio-methanation. Among these techniques, co-firing technique is considered as the best technique for biomass conversion.

1. Co-Firing

Co-firing term is also called co-combustion. It is a method of combustion of two distinctfuelsin a commonboiler. Inothers words,co-firing with biomass is theprocessof the partialsupplementingof coal with the solid biomass residuesin accessible thermalplants.One of the advantages of co-firing is that an existing plant can be used to burn a new fuel, which may be cheaper or more environmentally friendly. Co-firingtechnology is veryflexible. It means that if there is no biomass supply due to some reasons, then the plantcanalso be workat100%load.

1.1. Co-Firing Technology for Coal and Biomass

The biomass co-firing in thermal plants can be applied in three basic configurations, are as follows:

1.1.1. Direct Co-firing
1.1.2. Indirect Co-firing
1.1.3. ParallelCo-firing

1.1.1.Direct Co-firing – It is simple and least cost approach. Biomass fuels are blended with coal and blend is sent to the firing system.

1.1.2.Indirect firing – In this approach the biomass is separately injected into the boiler without impacting the coal delivery process. This method involves more equipment than the first approach.

1.1.3. Parallel Co-Firing- In this option, biomass is combusted in a separate boiler to produce low-grade steam for the utilization in the coal fired power plant.

2. EXPERIMENTAL WORK

A. Material Selection

In this work, two different types of non-woody biomass species (bagasse and rice husk) were collected from the local area and kept for air drying in a cross ventilated room for about 20-25 days. The moisture contents of these components reached in equilibrium. The air dried biomass samples were crushed into powders and then processed for their proximate analysis and calorific value determination. The sample of coal of grade E was also used to calculate their power value and proximate analysis.

B. Proximate Analysis

Analysis for moisture, volatile matter, ash and fixed carbon contents were carried out on samples ground to -72 mesh size by standard method [4]. The details of these tests are as follows.

2.1.1. Determination of Moisture

One gm. (1 gm.) of -72 mesh size (air dried) was taken in a silica disc and kept at 110°C temperature for 1 hr. in the hot air oven then taken out from the furnace and cooled in a desiccator. The percentage loss in weight gave the percentage moisture content in the sample.

$$\frac{\mathrm{Wi} - \mathrm{Wf}}{\mathrm{Wi}} * 100 = \mathrm{W1}$$

Where, W_f = final weight of sample

W_i = initial weight of sample

W_1= percentage of moisture present in sample

2.1.2. Determination of the Ash Content

One gm. (1 gm.) of -72 mesh size (air dried) was taken in a silica disc andkept in the muffle furnace maintained at the temperature of 700°C.The sample was kept in the furnace till complete burning or two hours and then residues were taken out from the muffle furnace and then cooled it for half hour in the air. Weight of ash formed was noted down and the percentage ash content in the sample was determined.

$$\%\,\text{Ash} = \text{Weight of residue obtained} \times 100 \,/\, \text{Initial weight of sample}$$

2.1.3. Determination of Volatile Matter

One gm. (1 gm.) of -72 mesh size (air dried) was taken in a volatile matter crucible (cylindrical in shape and made of silica). The crucible is covered from top with the help of silica lid and kept in the muffle furnace maintained at the required temperature of 925°C for seven minutes. The volatile matter crucibles were then taken out from the furnace and cooled in air and then selected samples were weighted in electronics balance weighing machine and calculate weight loss percentof selected sample.

$$\%\,\text{VM} = \%\,\text{loss in weight} - \%\,\text{moisture content}$$

2.1.4. Determination of Fixed Carbon

The fixed carbons in the simple were determined by using the following formula.

$$\%\,FC = 100 - (\%\,M + \%\,VM + \%\,Ash)$$

Where,FC: Fixed carbon,M: Moisture,VM: Volatile Matter

C. Determination of Calorific Value

The calorific value of the above said components of size -72 mesh were calculated by oxygen bomb calorimeter equipment. The formula to calculate power value of selected components was given in the following.

$$\text{"GCV = "} \{(\text{"waterequivalent} \times \Delta T\text{"})\text{"} - \text{"} (\text{"heatliberatedbythethreadofcotton} + \text{heatliberatedbynicromewire"})\} / (\text{"Initialwt. ofsample"})$$

Where ΔT is the maximum rising temperature

3. RESULTS AND DISCUSSIONS

A. Proximate Analysis and Calorific Value

The study of proximate analysis and calorific value of fuels are very important because it gives an idea about the energy value and also for judging their qualities for electricity generation. The proximate analyses and calorific value of different agricultural biomass residue and these biomass residues components with coal are presented in Tables 1-3.

Table 1: The Calorific Values and the Proximate Analysis of Sugarcane Bagasse, Rice Husk and Coal

Component	Proximate analysis wt. %, air dried basis				Calorific value (kcal /kg, dry basis)
	Moisture	Volatile matter	Ash	Fixed carbon	
Sugarcane					
Bagasse	2.33	78.34	4.43	14.9	4151.265
Rice					
Husk	4.85	60.82	17.68	16.65	3437.432
Coal Grade E					
Coal Mines(Jharkhand)	1.65	27.70	35.9	34.75	4661.802

The calorific values and proximate analysis of mixed coal-biomass fuels (coal-bagasse and coal-rice husk) in the various ratios are presented in Tables 2 and 3.

Table 2: The Calorific Values and the Proximate Analysis of mixed Coal-Bagasse in variance ratios

Ratio (Coal: Bagasse)	Proximate analysis wt. %, air dried basis				Calorific value (kcal /kg, dry basis)
	Moisture	Volatile Matter	Ash	Fixed carbon	
95:05:00	2.03	25.33	34.02	38.62	4601.053
90:10:00	2.18	27.87	33.43	36.52	4545.038
85:15:00	2.32	30.15	31.72	35.81	4414.523
80:20:00	2.48	32.56	30.23	34.73	4407.190

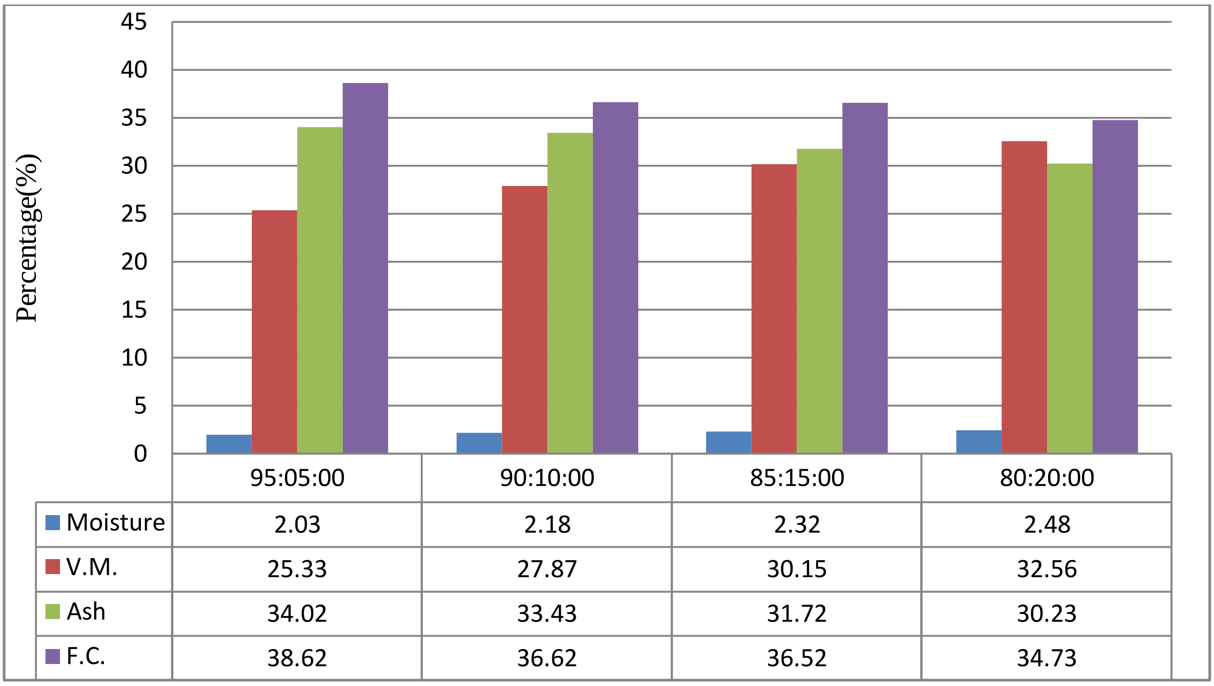
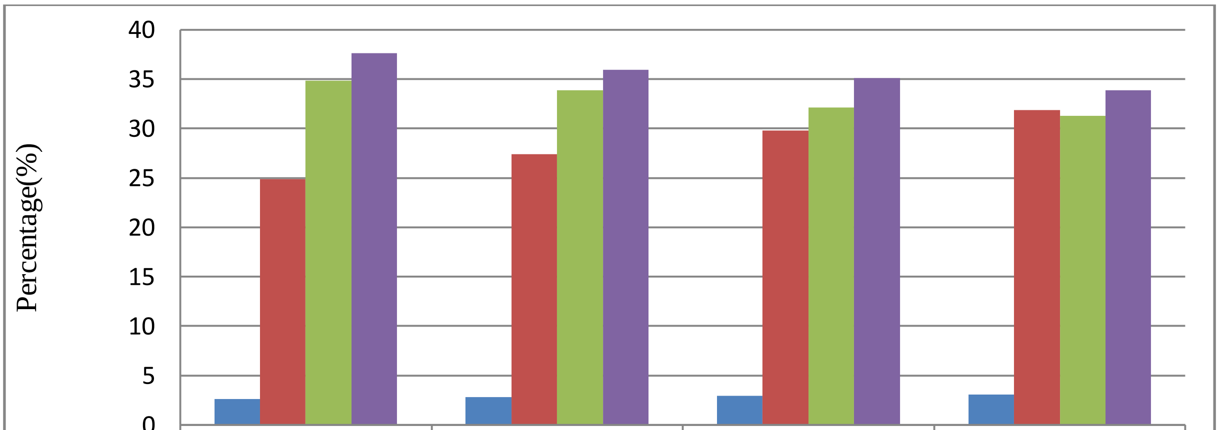


Figure 1: Variationof Proximate Analysis of the mixed Coal and Bagasse

Table 3: The Calorific values and the proximate analysis of mixed Coal - Rice Husk in variance ratios

Ratio (Coal : Rice husk)	Proximate analysis wt. %, air dried basis				Calorific value (kcal /kg, dry basis)
	Moisture	Volatile Matter	Ash	Fixed carbon	
95:05:00	2.68	24.86	34.82	37.64	4560.163

90:10:00	2.82	27.43	33.83	35.92	4504.122
85:15:00	2.97	29.79	32.14	35.10	4496.652
80:20:00	3.08	31.83	31.26	33.83	4463.070



	95:05:00	90:10:00	85:15:00	80:20:00
Mosture	2.68	2.82	2.97	3.08
V.M.	24.86	27.43	29.79	31.83
Ash	34.82	33.83	32.14	31.26
F.C.	37.64	35.92	35.1	33.83

Figure 2: Variation of Proximate Analysis of the mixed Coal and Rice husk

CONCLUSION

In the present work two non-woody biomass species Bagasse and Rice husk were selected & experiments to determine the proximate analysis & calorific values of the selected species were per-formed. The selected biomass residues were also mixed with coal in different ratios such as 95:05, 90:10, 85:15, 80:20 and experiments were done to determine the proximate analysis and calorific values.The following are the different conclusions drawn from the present work.

- **i.** Amongst the both biomass species Bagasse has higher energy values compared to Rice husk.
- **ii.** Both biomass residues has lower value of calorific, higher volatile matter and lower ash content than the coal sample.
- iii. Coal-Bagasse mixed has also higher calorific value, lower ash content, lower moisture content and higher volatile matter than mixed coal-rice husk.
- **iv.** Amongst the four different ratios 80:20 gives the higher moisture content, less ash content and higher volatile matter as compared to 95:05, 90:10, 85:15.

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